Center Innovation Fund: LaRC CIF

Doped Chiral Polymer Metamaterials (DCPM)

Completed Technology Project (2013 - 2015)

Project Introduction

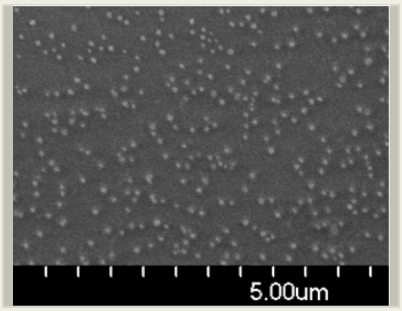
The goal of this research is to develop lightweight, flexible, compact metamaterials with tunable resonance frequencies for effective optical and communication tools in space exploration. Doped Chiral Polymer Metamaterials (DCPM) is developed by adding various plasmonic nano-inclusions into chiral polymers, amplifying the chiral parameter, while lowering the real part of the permittivity to create a metamaterial without having a negative permeability or geometrically complex architecture.

Metamaterials are a new class of materials with exotic electromagnetic properties not found in any naturally occurring material.

The DCPM was developed to exhibit reduced refractive index (<1.0) and tunable optical properties by controlling chiral parameter (k) and the real permittivity (ε') without a complex architecture or a geometry. No negative permeability is required for DCPM. Chiral polymers with helical structures were employed to increase the chiral parameter while suppressing permittivity. Various plasmonic inclusions (Ag, Au) were incorporated into the chiral polymer matrix to suppress the permittivity and increase chirality at resonance frequencies using a supercritical fluid (SCF) infusion method or in-situ mixing. Refractive indexes below 1 at resonance frequencies were achieved for a chiral polymer by adding plasmonic nanoparticles. Drawing DCPM further decreased the refractive index at non-resonant frequencies while increasing chirality. Preliminary studies including a proof-of-concept demonstration were successfully performed with a UV chamber with several laser sources and a variable laser system to study reduction in the refractive index of the DCPM. Flexible, lightweight, compact DCPM would potentially enable various applications such as a wireless antenna suit, radio astronomy spectroscopy, non-destructive testing of spacecraft, security detection of chemicals, electromagnetic cloaking devices, reduction of energy/power beam dispersion, UV beam collimators (beam alignment, power beam transmission, energy power beaming, deep space communications), sub-wavelength high resolution imaging, compact optics systems for sensors, novel beam steering control for lasers and novel space telescopes.

Anticipated Benefits

Flexible, lightweight, compact DCPM potentially enables applications such as a wireless antenna suit, radio astronomy spectroscopy, security detection of chemicals, reduction of energy/power beam dispersion, UV beam collimators (beam alignment, power beam transmission, energy power beaming, deep space communications), and compact optics systems for sensors.



Project Image Doped Chiral Polymer Metamaterials

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Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Center / Facility:

Langley Research Center (LaRC)

Responsible Program:

Center Innovation Fund: LaRC CIF

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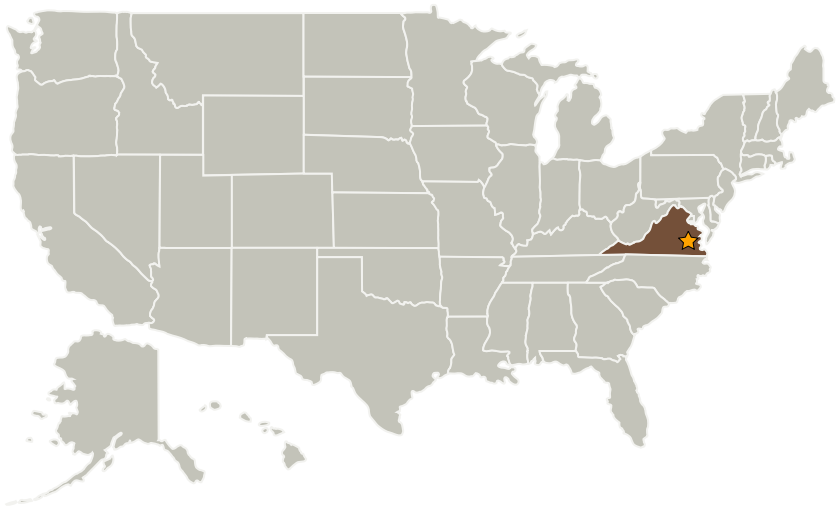
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
★Langley Research Center(LaRC)	Lead Organization	NASA Center	Hampton, Virginia

Co-Funding Partners	Type	Location
National Institute of Aerospace	Academia	Hampton, Virginia
University of Illinois at Urbana-Champaign	Academia	Urbana, Illinois

Primary U.S. Work Locations
Virginia

Project Management

Program Director:
Michael R Lapointe

Program Manager:
Julie A Williams-byrd

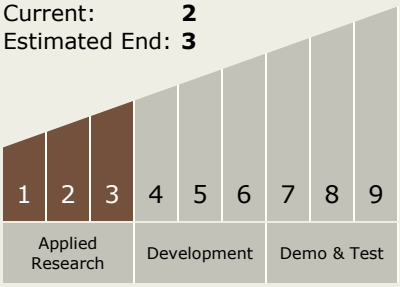
Project Manager:
Keith L Gordon

Principal Investigator:
Keith L Gordon

Co-Investigator:
Cheol Park

Technology Maturity (TRL)

Start: **1**
Current: **2**
Estimated End: **3**



Technology Areas

Primary:

- TX12 Materials, Structures, Mechanical Systems, and Manufacturing
  - TX12.1 Materials
    - TX12.1.7 Special Materials

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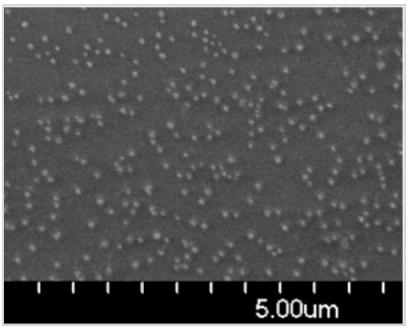
Images



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Project Image Doped Chiral Polymer Metamaterials
(https://techport.nasa.gov/image/2287)